

**REPORT FROM THE**

**SUBCOMMITTEE ON LIFTBOAT OPERATIONS**

**TO**

**THE NATIONAL OFFSHORE SAFETY ADVISORY**  
**COMMITTEE**

**OF THE**

**UNITED STATES COAST GUARD**

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**WASHINGTON, D.C.**

# National Offshore Safety Advisory Committee (NOSAC)

## Task Statement for the Subcommittee on Liftboat Operations

### I. Task Title

Liftboat operations with respect to leg and base pad design.

### II Purpose

The Coast Guard is seeking **information** and appropriate **recommendations** on liftboat leg design and base pad/seafloor interaction during various operational events, respectively, particularly pre-load, initial & subsequent bottom penetration while elevated, and extraction during jack-down.

### III Background

*Recent casualties involving liftboats have led the Coast Guard to question the adequacy of current design standards for liftboats. As a result of these casualties the Coast Guard created this task force to investigate the adequacy of current liftboat design standards.* The task force, which volunteered to assist the Coast Guard with this project represented over 90% of the liftboats operated in the Gulf of Mexico and included input from major liftboat designers.

Liftboats are unique service vessels that continue to evolve into larger vessels capable of operating in deeper waters. Modern designs are generally larger than the contemporary designs of the late 1980s/early 1990s, when the current design and operation regulations were developed.

One area where this evolution is significant is **leg and pad design**, which is critical to the elevated stability, and safety, of the liftboat. Most elevated casualties appear to be associated with seafloor soil conditions and an event commonly referred to as “**punch-through**”. The industry's strategy to avoid such casualties is to conduct pre-load operations to verify the seafloor load bearing capacity.

The intent of this task analysis is to proactively focus both USCG and industry's attention on this issue, and jointly identify any related adverse design or operational trends. The Coast Guard is not anticipating any regulatory action as a result of this review, but rather looking to identify areas (if any) where, if possible, enhanced design practices and inspection procedures can be productively implemented, voluntarily.

### IV. Problem

***Historically, liftboats were uninspected vessels used to service shallow water oil wells. Due to a number of casualties, liftboats were brought under inspection by the Coast Guard to address perceived problems related to vessel operations, stability and construction. The Coast Guard believed that these newly implemented standards would eliminate liftboat casualties. Three recent casualties involving vessels constructed after the implementation of design standards has caused the Coast Guard to question the adequacy of these standards.***

There are several specific areas where the Coast Guard would like better information on industry practice, both, with respect to leg/pad design and operational mechanics impacting regarding leg and base pads. In the task assignment, these are posed as questions:

### **Design practices**

*1) How are base pads sized (i.e., assumed bearing capacity of seafloor, development of fixity, limiting penetration, physical constraints dictated by hull form, etc)? Is there a particular trend as legs are designed for deeper waters?*

Basically, the intended area of operation drives pad design. For the Gulf of Mexico, which generally has soft bottoms, the pads are sized to reduce bearing pressures to an agreed upon level. The pad will be rectangular in form to achieve this bearing area and is designed to fit into the hull form and reduce the amount of pad that extends beyond the side of the hull. If a vessel were being designed for operation on hard bottoms, the pad size would be significantly smaller and more closely resemble a spud can as seen on jack up rigs.

There is no particular trend as legs are designed for deeper water. We are, in fact, seeing a variety of methods used for leg design. They range from lesser diameter, thicker wall legs to larger diameter, thinner wall legs. Both meet the requirements of regulatory bodies.

While leg design may vary, large diameter legs with thinner wall design, or smaller leg diameter with thicker wall design, all meet the regulatory requirements of leg design strength.

*2) What are the governing considerations for designing the pad/leg connection (i.e., fixity, eccentric loading, fatigue cycle, etc.)?*

All of the above are considerations in designing the pad/leg connection. Even if fixity was not a final consideration in the design of the leg, (although fixity is considered in all designs) the size of the pad with respect to the leg dictates that some type of bottom constraint be assumed to check not only the leg to pad connection but the bending strength of the pad itself. The typical design of the leg to pad connection is a connection design that can develop the full strength of the leg section to which it is attached. Most designers continue the leg can completely through the pad and design the surrounding pad to handle the maximum bending moment that the leg can withstand. Fatigue has not proven to be a problem under the moderate sea conditions of the Gulf of Mexico.

3) *How is pre-load capacity determined (i.e., size of ballast tanks)? Is it based on maximum static load, or dynamic loading (i.e., cyclical wind/wave forces)?*

Preload is based upon the combination of dynamic conditions that a vessel may expect. Preload capacity, fundamentally, is based on the maximum increase in load on the most heavily loaded leg whether from the design environment criteria or live loading such as a heavy crane lift. The amount of preload taken on is based on the need to simulate this load in the legs and is determined by the weight on board at the time of the preload operation plus the added footing loadings that may be anticipated due to the overturning effects of wind, wave and current loading. As a design consideration, and a safety factor, it is assumed that all influences such as wind, wave and current are acting simultaneously in the same direction. Adequate factors of safety on preload values are dependent on operational conditions, soil conditions, and knowledge available to the operator regarding the soil conditions in the area.

4) *What seafloor soil information is usually available when the liftboat arrives on-site?*

Vessel operators usually request 3 types of information:

- a) Bottom or diver's survey to identify seafloor obstructions and assist in vessel positioning.
- b) Subsurface soil bearing data to make penetration estimation and identify subsurface soil anomalies.
- c) Platform structural diagrams showing skirt piles and other possible impediments.

While soil and bottom survey information is often requested by liftboat operators and usually provided prior to going on location, the provision of this information is not mandated by MMS regulations. Soil data is often available, but it remains an inexact science. Provision of operational data from boat operators who have been on location previously would be an asset to site planning operations. Industry is, collectively, identifying and enhancing resources and expanding access to such information, and application thereof.

5) *What are general practices with respect to pre-loading (i.e., length of time)?*

Preloading is the safety procedure used to assess the load bearing capacity of the soil, to achieve maximum penetration, viz, to compress the soil to hold the maximum weight expected, to prevent unexpected leg penetration (punch through) during operations, in order to prevent damage to the vessel and injury to the crew.

Generally, vessels (class 145' and larger) go through a pre-load procedure, which entails jacking to wave tops and taking on an amount of pre-load water (based on water depth and variable load as prescribed in the operations manual). As the pre-load water is loaded and following loading, settling of pads into the seafloor is regularly and intensely monitored. Once initial settling stops, typically a minimum of an additional 6 hours is observed to determine if any further settling has occurred and more time is spent observing until settling ceases, at which point pre-load ballast water is released and work operations begin.

6) *Once elevated, how often is the air gap/pad penetration checked? How is levelness monitored?*

Air gap and pad penetration are monitored continuously, although indirectly, through the use of automatic tilt/level indicators. Manual tilt/level bubble indicators are located on the vessel bridge. The manual indicators are checked as a matter of course whenever personnel are on the vessel bridge and, typically, are regularly checked while in pre-load mode.

Once up to operating heights, air gap monitoring is no longer specifically monitored but levelness is continuously monitored by the automated system. While it may be technically possible for a vessel to sink identically on all legs simultaneously, as a practical matter, this has never been known to occur, and if it did occur would not present an extreme safety hazard. The danger of leg failure primarily occurs when one leg sinks while the others remain fixed, creating unnatural stresses on the structure.

In accordance with most standard operating manual procedures, if a tilt alarm sounds, the responsible crewmember (master or mate) will determine if leveling is required. If any leveling procedure is required, the crewmember (master or mate) will typically alert the vessel crew and industrial personnel by general alarm to muster with lifejackets on until the leveling process is complete, i.e. the rule of thumb, and our recommendation, is that if the jacking gear is to be engaged, the general alarm will be sounded as a matter of course, and all personnel aboard will be mustered with lifejackets on.

7) *How deep do pads penetrate (both typical & extreme)? Do pads continue to penetrate over time? Do they penetrate equally, or does one pad typically penetrate deeper (i.e., the stern pad, the leeward pad, etc)?*

Pad penetration is typically around 5 to 8 feet. In extreme cases, penetration has been as little as zero feet on hard sand bottoms and up to 70 ft of penetration in the soft soils off the mouth of the Mississippi river. Due to the soil compaction process of pre-load, pads typically do not continue to penetrate over time after pre-load is complete. Soil conditions typically do not vary significantly over the relatively small area of a liftboat where pads normally penetrate equally, the usual exception is when a pad is in a can-hole created on that location by a previous vessel where, in those cases a pad may sit lower (in the can-hole 'crater') but usually does not penetrate as much due to pre-compaction of soil by the previous can. **The industry has begun the compiling of a liftboat leg penetration database, and of 150 Gulf of Mexico penetration data points analyzed to date, almost half (68/150) show shallow penetrations of 5 feet or less.**

The subcommittee has not discovered information that any leg (port, starboard, aft) is typically more likely to penetrate deeper than the others and/or suffer "punch through". The legs on liftboats are independent so that differing load distribution, uneven seafloor configuration or penetration is not in and of itself a problem. The preload process evenly balances the expected loads on each of the legs. **The real problem is when a sudden change occurs in the penetration of a single leg (no dual leg punch-through is known) during the pre-load process or after the vessel has been set and working on location. When this**

**sudden change in penetration (punch-through) occurs, at a rate faster than the ability of the operator to compensate (jack up or jack down as needed), unnatural stresses are placed on the vessel structure and/or machinery causing a failure (6 feet per minute is the typical jacking rate).**

Simply put, “punch-through” is the issue, and the relevant threat to safety, not “penetration”, per se.

***A table and Excel spreadsheet data has been included showing the penetration data that the industry has collected and is sharing to date.***

*8) What does it take to extract an imbedded pad? How long does it take? Do operating manuals provide guidance on this activity?*

Industry operations manuals have procedures and operational guidance for removing legs from the soil. A vessel is lowered into the water where leg extraction is based on buoyant upward pressure and time. The optimum extraction comes from submerging the vessel to the point no deeper than the deck is at/near water level and thus applies an upward pressure on the pads to get them to lift out of the soil. Time is then required for the pressure beneath the pad to equalize pressure above and below the pad and release the pad from the soil.

Extraction times vary from no time at all on sandy bottoms to several hours in thick, silty soils.

Operating manuals provide information on maximum environmental conditions (wind, waves) for going “on location” (jacking up) or going “off location” (jacking down). There may be need to give more explicit guidance as to the 'unnatural' (torque) forces that can be inadvertently put onto the leg/pad interface during extraction or unnatural compression forces experienced going on location in excessive sea states.

*9) What type of weather forecast triggers a decision to jack down and flee? How long in advance? To what extent is this decision influenced by other factors (i.e., oil rig operator wants liftboat out of harm's way from his rig). How common is it to just evacuate the crew & leave the liftboat on site?*

The only weather condition that triggers a decision to leave location is a “named” storm in the Gulf of Mexico.

Tropical storms entering into the gulf or an extreme weather system while elevated in water near maximum depth and air-gap may not be sufficient to trigger a decision to abandon location. Decisions are implemented 24-48 hours prior to the arrival of any weather system, or when any named storm enters into the gulf. Evacuation of crew and abandonment of vessel is NOT common and NOT a preferred option.

**It should be noted that the vessel is designed to be safest while elevated. If the sea state or operations do not allow the vessel to be moved from location to harbor, the personnel**

**may be evacuated and moved to safe location. In the last 10 years, it should be noted that OMSA members, representing 90% of the liftboat community offshore, have suffered severe damage or lost only three liftboats that were elevated to storm level and evacuated, with no injury or loss of life. Therefore, while personnel may be evacuated, vessels will typically be left on location in those particular circumstances. That practice appears to be logical and operationally sound.**

*10) How long does a "routine" jack-down take (i.e., from decision to depart until boat is afloat and ready to get under way, including extraction time and other preparations)?*

The limitations on vessel movement are more often than not controlled by the ability to secure the industrial operations that the liftboat is supporting rather than the technical abilities of the liftboat. While a vessel may be able to jack-down in as little as 45 minutes on sandy soil or up to 8 hours or more if a leg is stuck, there are other variables. The industrial operation that a liftboat may be supporting (such as coiled tubing) could take up to 12 hours or more to rig down and secure for vessel movement. Therefore, it is apparent that there are many variables involved and options to consider with respect to time sensitive decisions. The liftboat industry is the most logical party to discern what constitutes safe operations within the context of those variable circumstances.

*11) What is the historical experience with leg structures (i.e., cracking, flooding, deformation, etc)?*

Cracking is usually located in way of the jacking rack termination, and in way of internal support "hard" spots and is typically caused by:

- a) inadequate welding procedures and deficient quality control during construction
- b) deformation (bending) of the legs when jacking up/down in sea states that exceed the operations manual standards
- c) deformation (bending) of the legs when running in sea states that exceed the operations manual standards (leg whip)
- d) deformation (bending) of the legs caused by physical damage due to vessel collision
- e) if a single leg is stuck going off location it may be rocked or twisted during retrieval if the other legs are not promptly returned to the seafloor.

Flooding comes from cracks in the leg material or punctures in the pads due to setting down on seafloor debris. Most, if not all, are related to operational accidents or practice breakdowns rather than design problems.

Very few occurrences of leg and pad problems have been experienced. Those notable instances where problems do occur include pad punctures due to seafloor debris; leg deformation due to a pad sliding into an existing can-hole from a jack-up rig; and cracks in legs at rack-segment butts which was proved to have been a localized material flaw. In cases of cracked legs and/or punctured pads, the first indicator of a problem was a post-extraction "list" of the vessels due to water in the leg.

V. Task:

A. Description: Develop a report that addresses the questions outlined above; include recommendations as appropriate.

***The task force examined the casualties that led to the formation of this NOSAC tasking and compare them to the historical casualties that led the Coast Guard to implement liftboat design standards. The task force agreed that current vessel design standards, operating standards and general industry practice are superior to historical standards and practice prior to the Coast Guard bringing liftboats under inspection. The examination of casualties that led to this tasking revealed two general causes. Those two general areas were soil/bottom/leg interaction (punch-through) and human error, each of which is the subject of task force recommendations.***

***During the November NOSAC liftboat subcommittee meeting in Houston much discussion centered on the Coast Guard's increase in liftboat steady state wind speed design criteria from 50 knots to 70 knots. The industry consensus, supported by analysis of Gulf of Mexico data buoy data, is that this change was and remains unnecessary. An examination of the data collected by data buoys in the Gulf of Mexico shows that surface wind gusts (unlike steady winds aloft reported during hurricane coverage) seldom exceeded 50 knots. While the industry examination of this empirical data suggests the discussion of design wind speed criteria has great merit, it is not a part of this tasking and therefore tabled for future discussion.***

The task force considered the basic premise of this NOSAC tasking and found no evidence to conclude that design flaws in any way contributed to any of the vessel casualties that led the Coast Guard to institute this investigation into liftboat design and/or operations. ***The vessel operating company that is the subject of several recent casualty investigations contracted with a prestigious European design firm to review data surrounding the casualties and determined that leg design was not a factor in the casualties.*** The task force believes current design standards are generally safe and sufficient.

The Liftboat task force has, in accordance with its assignment by the committee, addressed all of the pertinent questions. After a thorough review of recent accidents and incidents, no incident that has been studied, relates specifically or peripherally to inherent problems with leg or foot design. The task force has concluded that all legs and pads on vessels involved in said accidents were designed and built in accordance with the rules and regulations and that leg and/or pad design was not a contributing factor in structural failures associated with the leg and/or pad. It is the consensus of the NOSAC subcommittee on Liftboat operations, representing the significant majority of the offshore liftboat fleet, that the current design practices for the Liftboat Industry have proven to be safe and that it is unlikely that these designs will trend to undetected leg/pad cracking which would lead to sudden, expected structural failures while elevated. The task force considered the basic premise of this NOSAC tasking and found no evidence to conclude that design flaws in any way contributed to any of the vessel casualties that led the Coast Guard to institute this investigation into liftboat design and/or operations.

The analysis by the task force has produced a number of operational recommendations, nevertheless, which should enhance the level of safety in liftboat operations. ***The liftboat operators that participated in this project have committed to cooperate to address the recommendations contained in this report and may consult with the drilling industry to determine if there are any operating procedures/standards that may be applied to the liftboat industry. The liftboat task force has been working and will continue working with companies that provide bottom survey data and soil condition data to develop better data on the Gulf of Mexico.***

## **RECOMMENDATIONS:**

1. The committee would recommend to the industry that an examination be made of all vessel pre-load wording (in operations manuals) with an eye towards redesigned/worded preload instructions that specifically address issues to prevent or minimize the effects of punch-through during preload. Such changes as a two-stage preload and reduced pre-load height may reduce incidents.
2. The committee would recommend to the industry that an examination be made of the quality control language in shipyard contracts and prepare standard quality control language and 3<sup>rd</sup> party quality control oversight for all contracts that include fabrication or welding.
3. The committee would recommend to the industry that an examination be made of standard contract language that would require better/additional/more complete operating location information, including the experience of prior operators on the location, if available. The committee believes that information sharing on penetration rates, bottom conditions, soil condition, etc. of prior operators will allow for better site planning. While the committee acknowledges that soil sampling and penetration calculations are not an exact science, it is believed that the additional information will assist the operators in site planning and minimize risk. The Coast Guard may want to meet with MMS personnel regarding a requirement for leaseholders to provide collect and provide such information to the boat operators. The OMSA Liftboat Committee will discuss and attempt to develop computer-generated information/resources to date, record and store such information.
4. The committee would recommend to the industry that industry-wide changes to the operations manual requirements for action to take upon tilt alarm (muster at abandon locations if leveling action required), the addition of increased numbers of tilt alarm enunciators, increased number of general alarm enunciators, improvements to emergency notification and egress (more alarm bells, more emergency lights) would improve the industry's reactions to these unplanned events.
5. The committee would recommend adding a specific exercise, dedicated and tailored to "punch through" drills to the required abandon ship drill list. The OMSA Liftboat

committee is contemplating development of an operations orientation video on “punch through” situations (See 8 below), and other drills.

6. The committee would recommend companies review lifesaving appliance locations for float-free in the case of sinking at an extreme angle.
7. The committee would recommend that companies examine their procedures for possible changes to the location abandonment/field move procedures (jacking down procedures and leg freeing procedures) to lessen the likelihood that unnatural stresses could be placed on hull or machinery.
8. The committee would recommend development of an industry-wide orientation video to be shown to new hires and industrial personnel covering such things – emergency procedures, operations manual, leg freeing procedures, environmental protection (garbage, oil, sewage), crew and passenger orientation, as operations training guidelines and orientation.

The NOSAC liftboat taskforce respectfully submits this report in compliance with its assignment to provide information and/or recommendations with respect to the adequacy of contemporary liftboat leg and pad design standards and base pad/seafloor interaction during various operational events. The task force remains at the disposal of the committee.